

CLAIMS

1) A method of constructing a pile foundation; the method comprising the steps of building on the ground (2) a foundation structure (1) having at least one through hole (4); inserting a metal pile (3), comprising a rod (9) and at least one bottom main head (10), through said hole (4), so that the main head (10) of the pile (3) contacts the ground (2); statically applying at least one thrust on the pile (3) to drive the pile (3) into the ground (2); and fixing the driven pile (3) axially to the foundation structure (1); the method being characterized in that the transverse dimensions of the main head (10) are greater than those of the hole (4) when driving the main head (10) into the ground.

2) A method as claimed in Claim 1, wherein the main head (10) is initially detached from the rod (9), and, when building the foundation structure (1), is positioned contacting the ground (2) beneath the foundation structure (1) and substantially coaxial with the hole (4); the rod (9) engaging the main head (10) when the rod (9) is inserted through the hole (4).

3) A method as claimed in Claim 1, wherein the transverse dimension of the main head (10) is adjustable, and the main head is contracted to a transverse dimension smaller than that of the hole (4) for insertion through the hole (4), and is then expanded to a transverse dimension larger than that of the hole (4) on contacting

the ground (2).

4) A method as claimed in Claim 3, wherein the transverse dimension of the main head (10) is adjusted by means of an actuator producing relative slide between at least two portions of the main head (10).

5) A method as claimed in one of Claims 1 to 4, wherein at least one connecting member (5) is fixed to the foundation structure (1), adjacent to the hole (4); the static thrust on the pile (3) to drive the pile (3) into the ground (2) being applied using the foundation structure (1) as a reaction member.

6) A method as claimed in Claim 5, wherein appropriate ballast, resting on the foundation structure (1), is added to the foundation structure (1) at the hole (4).

7) A method as claimed in one of Claims 1 to 6, wherein drive ballast, physically separate from and not resting on the foundation structure (1), is provided; the static thrust on the pile (3) to drive the pile (3) into the ground (2) being applied using the drive ballast as a reaction member.

8) A method as claimed in Claim 7, wherein the drive ballast comprises a mass resting on the ground (2).

9) A method as claimed in Claim 8, wherein the mass of the drive ballast is fixed temporarily to the ground (2) by means of a number of auxiliary piles or screws driven temporarily into the ground (2).

10) A method as claimed in Claim 8 or 9, wherein the

mass of the drive ballast is mounted on a movable structure.

11) A method as claimed in Claim 10, wherein the mass of the drive ballast is supported on wheels.

5 12) A method as claimed in Claim 10, wherein the mass of the drive ballast is supported on a floating body.

13) A method as claimed in Claim 7, wherein the drive ballast comprises a number of auxiliary piles
10 driven temporarily into the ground (2).

14) A method as claimed in one of Claims 1 to 13, wherein thrust is applied by means of a respective thrust device (21) located over the rod (9) and cooperating with a top end (22) of the rod (9).

15 15) A method as claimed in one of Claims 1 to 13, wherein thrust is applied by means of a respective thrust device (21) comprising at least two hydraulic jacks located on opposite sides of the rod (9).

16) A method as claimed in Claim 15, wherein the
20 movable output member of each hydraulic jack is fixed to a fixed horizontal plate, and the bodies of the two hydraulic jacks grip the rod (9) to engage the rod (9) and draw the rod (9) downwards when the output members of the jacks are extracted from the bodies of the hydraulic
25 jacks.

17) A method as claimed in Claim 16, wherein the bodies of the two hydraulic jacks grip the rod (9) by means of wedges, which tend to compress the rod (9) as

the bodies of the hydraulic jacks descend.

18) A method as claimed in one of Claims 1 to 17, wherein the main head (10) comprises a connecting member (14) for engaging the rod (9) and fixing the rod (9) transversely to the main head (10).

19) A method as claimed in Claim 18, wherein the rod (9) is defined by a cylindrical pipe having an inner conduit (11); the connecting member (14) being defined by a cylindrical member which engages a bottom portion of the inner conduit (11).

20) A method as claimed in one of Claims 1 to 19, wherein the rod (9) is defined by a cylindrical pipe having an inner conduit (11).

21) A method as claimed in Claim 20, wherein, once driving is completed, a substantially plastic first cement material (32) is fed into the inner conduit (11).

22) A method as claimed in Claim 21, wherein the first cement material (32) is defined by concrete.

23) A method as claimed in one of Claims 1 to 19, wherein the rod (9) is defined by a section.

24) A method as claimed in one of Claims 1 to 23, wherein the main head (10), as it is being driven, forms in the ground (2) a main channel (28) of larger transverse dimensions than the rod (9); a substantially plastic second cement material (31) being fed into the portion (30) of the main channel (28) not occupied by the rod (9).

25) A method as claimed in Claim 24, wherein an

injection conduit (16) is formed through the foundation structure (1), and has a first end (18) projecting from the foundation structure (1), and a second end (19) terminating on the ground (2) adjacent to the hole (4) and at the pertinent portion of the main channel (28);
5 the second cement material (31) being pressure injected into the main channel (28) along the injection conduit (16).

26) A method as claimed in Claim 25, wherein, prior
10 to driving the pile (3), any water beneath the foundation structure (1) is sucked out along the injection conduit (16).

27) A method as claimed in Claim 24, wherein the second cement material (31) is pressure injected by means
15 of an injection conduit (50), which is defined by at least one pipe (51) having a bottom end located at least one through hole (52) in the rod (9).

28) A method as claimed in Claim 27, wherein the through hole (52) in the rod (9) is located close to the
20 main head (10).

29) A method as claimed in Claim 27 or 28, wherein the rod (9) comprises a number of through holes (52) at the same height.

30) A method as claimed in Claim 27 or 28, wherein
25 the rod (9) comprises a number of through holes (52) located at different heights along the rod (9).

31) A method as claimed in one of Claims 27 to 30, wherein the second cement material (31) is pressure

injected by means of the injection conduit (50) when driving the pile (3) in a number of non-simultaneous stages.

32) A method as claimed in one of Claims 27 to 30,
5 wherein the second cement material (31) is pressure injected by means of the injection conduit (50) after the pile (3) is driven.

33) A method as claimed in one of Claims 27 to 32,
wherein, prior to driving the pile (3), any water beneath
10 the foundation structure (1) is sucked out along the injection conduit (50).

34) A method as claimed in one of Claims 24 to 33,
wherein the second cement material (31) is defined by betoncino.

15 35) A method as claimed in one of Claims 24 to 34,
wherein the hole (4) is fitted inside with a sealing ring (15) which engages the outer cylindrical surface of the rod (9) when the rod (9) is inserted through the hole (4).

20 36) A method as claimed in one of Claims 24 to 35,
wherein at least one additive is added to the second cement material (31) to reduce potential adhesion of the ground (2) to the second cement material (31).

37) A method as claimed in one of Claims 24 to 35,
25 wherein at least one waterproofing additive is added to the second cement material (31) to make the second cement material (31) substantially impermeable to water even prior to curing.

38) A method as claimed in Claim 37, wherein, when working through a bed of moving water, the second cement material (31) is injected at a pressure higher than the pressure exerted by the moving water.

5 39) A method as claimed in one of Claims 1 to 38, wherein at least one connecting member (5) is fixed to the foundation structure (1), adjacent to the hole (4); the pile (3) being fixed axially to the foundation structure (1) by securing to the connecting member (5) a
10 horizontal metal plate (33) placed on top of the pile (3) to engage a top end (22) of the pile (3).

40) A method as claimed in Claim 39, wherein a body of elastic material is interposed between the metal plate (33) and the top end (22) of the pile (3).

15 41) A method as claimed in one of Claims 1 to 40, wherein at least one connecting member (5) is fixed to the foundation structure (1), adjacent to the hole (4); the connecting member (5) being defined by a cylindrical metal lining pipe (5), which lines the hole (4), has a
20 portion (7) projecting upwards from the foundation structure (1), and is fixed to the foundation structure (1).

42) A method as claimed in Claim 41, wherein the metal pipe (5) is fixed to the foundation structure (1)
25 by at least one metal ring (6) integral with the foundation structure (1).

43) A method as claimed in Claim 42, wherein the metal pipe (5) is fixed to the foundation structure (1)

by at least two metal rings (6) integral with the foundation structure (1); an insulating sheath (48) being interposed between the foundation structure (1) and the ground (2); and the insulating sheath (48) being fixed,
5 at the hole (4), to the metal pipe (5) by inserting the free edge of the insulating sheath (48) between the two rings (6), and inserting through the insulating sheath (48) a number of screws (49), each of which is bolted to the two rings (6).

10 44) A method as claimed in one of Claims 1 to 43, wherein the rod (9) is made of metal, and comprises a number of segments, which are driven successively through the respective said hole (4), and are joined to one another to define the rod (9).

15 45) A method as claimed in Claim 44, wherein the segments defining the rod (9) are identical.

46) A method as claimed in Claim 44, wherein the segments defining the rod (9) differ in shape and/or thickness.

20 47) A method as claimed in one of Claims 1 to 46, wherein the main head (10) comprises a substantially circular, flat plate (12) having a jagged outer edge (13).

48) A method as claimed in one of Claims 1 to 47,
25 wherein the pile (3) comprises at least one lead-in head (34) coaxial with and below the main head (10), which has a central opening (37); the lead-in head (34) comprising an elongated body (36), which extends upwards through the

central opening (37) in the main head (10) and engages a bottom end (38) of the rod (9).

49) A method as claimed in Claim 48, wherein the main head (10) engages the rod (9) with the interposition
5 of at least one portion (39) of the elongated body (36) of the lead-in head (34).

50) A method as claimed in Claim 49, wherein the rod (9) is defined by a cylindrical pipe having an inner conduit (11); the elongated body (36) of the lead-in head
10 (34) being defined by a cylindrical tubular body (36), which is inserted inside the inner conduit (11) and comprises a ring (39) connected integrally to an outer surface of the tubular body (36) and which engages the bottom end (38) of the rod (9) to secure the rod (9)
15 axially to the tubular body (36); the main head (10) engaging the rod (9) with the interposition of the ring (39).

51) A method as claimed in one of Claims 48 to 50, wherein the main head (10) has a transverse dimension
20 larger than that of the lead-in head (34):

52) A method as claimed in one of Claims 48 to 50, wherein the main head (10) has a transverse dimension no larger than that of the lead-in head (34).

53) A method as claimed in one of Claims 48 to 52,
25 wherein the lead-in head (34), as it is being driven, forms in the ground (2) a lead-in channel (40) of transverse dimensions larger than those of an elongated body (36) connected to the lead-in head (34); a

substantially plastic second cement material (31) being fed into the portion of the lead-in channel (40) not occupied by the elongated body (36) simultaneously with the driving of the pile (3).

5 54) A method as claimed in Claim 53, wherein the second cement material (31) is pressure injected along an injection conduit, which is defined by at least one pipe having a bottom end located at the lead-in head (34).

10 55) A method as claimed in Claim 54, wherein the elongated body (36) is a tubular body having an inner channel along which the pipe defining the injection conduit is located.

56) A method as claimed in one of Claims 48 to 52, wherein the lead-in head (34) is fixed to a respective
15 elongated body (36) by means of a connecting mechanism allowing the lead-in head (34) to slide with respect to the elongated body (36).

57) A method as claimed in Claim 56, wherein the connecting mechanism is remote-controlled by an actuator.

20 58) A method as claimed in Claim 56, wherein the connecting mechanism releases slide of the lead-in head (34) with respect to the elongated body (36), when the force exerted on the lead-in head (34) exceeds a given threshold value.

25 59) A method as claimed in one of Claims 48 to 58, wherein the pile (3) comprises a number of lead-in heads (34) located coaxially with and beneath the main head (10), and which form in the ground (2) a lead-in channel

(40) defining a "lead-in" by which to drive the main head (10); the lead-in heads (34) increasing in transverse dimensions so as to gradually increase the transverse dimensions of the lead-in channel (40).

5 60) A method as claimed in one of Claims 48 to 59, wherein the bottom portion of at least the bottom lead-in head (34) is pointed.

61) A method as claimed in Claim 60, wherein the inclination of the pointed tip of the bottom lead-in head
10 (34) is adjustable, when driving the pile (3), as a function of the characteristics of the ground (2).

62) A method as claimed in Claim 60 or 61, wherein all the lead-in heads (34) are pointed.

63) A method as claimed in one of Claims 60 to 62,
15 wherein the bottom lead-in head (34) is rotated at a given speed about its central axis of symmetry.

64) A method as claimed in Claim 63, wherein the bottom lead-in head (34) comprises a number of helical grooves to screw the bottom lead-in head (34) into the
20 ground (2).

65) A method as claimed in Claim 64, wherein the bottom lead-in head (34) is screwed into the ground (2) with no extraction of material from the main channel (28).

25 66) A method as claimed in Claim 64, wherein the bottom lead-in head (34) is screwed into the ground (2) with extraction of material from the main channel (28).

67) A method as claimed in one of Claims 48 to 66,

wherein the transverse dimension of the lead-in head (34) is adjusted when driving the pile (3).

68) A method as claimed in Claim 67, wherein the transverse dimension of the lead-in head (34) is adjusted
5 by means of an actuator producing relative slide between at least two portions of the lead-in head (34).

69) A method as claimed in one of Claims 1 to 68, wherein the main head (10) is pointed.

70) A method as claimed in Claim 69, wherein the
10 inclination of the pointed tip of the main head (10) is adjustable, when driving the pile (3), as a function of the characteristics of the ground (2).

71) A method as claimed in Claim 70, wherein the inclination of the pointed tip of the main head (10)
15 clicks between at least two distinct configurations, so as to adjust, when driving the pile (3), to the characteristics of the ground (2).

72) A method as claimed in Claim 69, 70 or 71, wherein the main head (10) is rotated at a given speed
20 about its central axis of symmetry.

73) A method as claimed in Claim 72, wherein the main head (10) comprises a number of helical grooves to screw the main head (10) into the ground (2).

74) A method as claimed in Claim 73, wherein the
25 main head (10) is screwed into the ground (2) with no extraction of material from the main channel (28).

75) A method as claimed in Claim 73, wherein the main head (10) is screwed into the ground (2) with

extraction of material from the main channel (28).

76) A method as claimed in one of Claims 1 to 75, wherein a metal plate is placed about the hole (4), has a central hole corresponding with the hole (4), and is
5 connected to the foundation structure (1) by means of a number of screws.

77) A method as claimed in one of Claims 1 to 76, wherein, prior to fixing the pile (3) axially to the foundation structure (1), the pile (3) is preloaded with
10 a downward thrust of given intensity.

78) A method as claimed in one of Claims 1 to 77, wherein, when driving the pile (3), the rod (9) of the pile (3) is rotated about its vertical axis of symmetry.

79) A method as claimed in one of Claims 1 to 78,
15 wherein, prior to driving the pile (3), a pre-channel (45) is formed coaxial with the main head (10).

80) A method as claimed in Claim 79, wherein the pre-channel (45) has a transverse dimension slightly larger than the transverse dimension of the main head
20 (10), and the inner walls of the pre-channel (45) are lined with a sheet metal liner (48).

81) A method as claimed in Claim 79 or 80, wherein the pre-channel (45) is filled with low-strength material (46).

25 82) A method as claimed in one of Claims 1 to 80, wherein the transverse dimension of the main head (10) is adjusted when driving the pile (3).

83) A method as claimed in Claim 82, wherein the

transverse dimension of the main head (10) is adjusted by means of an actuator producing relative slide between at least two portions of the main head (10).

84) A method as claimed in Claim 82 or 83, wherein
5 the main head (10), as it is being driven, forms in the ground (2) a main channel (28) of transverse dimensions larger than those of the rod (9); a substantially plastic second cement material (31) being fed into the portion (30) of the main channel (28) not occupied by the rod (9)
10 simultaneously with the driving of the pile (3); the possibility of adjusting the transverse dimension of the main head (10), as the main head (10) is driven into the ground (2), being used to increase the transverse dimension of the main channel (28) at the end portion of
15 the main channel (28), so as to form a bulb of relatively large transverse dimensions at the bottom end portion of the pile (3).

85) A method as claimed in Claim 84, wherein the transverse dimension of the end portion of the pile (3)
20 is increased by drawing the main head (10) upwards to deform the end portion of the rod (9).

86) A method as claimed in one of Claims 1 to 85, wherein, prior to inserting the rod (9) inside the respective hole (4), an elongated member (53) is inserted
25 inside the hole (4), so that the elongated member (53) faces a through slot (54) formed in the main head (10) and shaped and sized to permit passage of the elongated member (53); a plate (55), having a transverse dimension

at least equal to that of the rod (9), being placed on top of the elongated member (53), and, when the rod (9) is inserted inside the hole (4), the bottom end of the rod (9) resting on the top surface of the plate (55) to
5 push the elongated member (53) down and bring the plate (55) into contact with the main head (10); as the plate (55) comes to rest on the top end of the main head (10), the downward thrust exerted on the rod (9) being transferred to both the main head (10) and the elongated
10 member (53), so that the main head (10) and the elongated member (53) sink together into the ground (2).

87) A method as claimed in one of Claims 1 to 86, wherein the main head (10) is fixed to the rod (9) by means of a connecting mechanism allowing the main head
15 (10) to slide with respect to the rod (9).

88) A method as claimed in Claim 87, wherein the connecting mechanism is remote-controlled by an actuator.

89) A method as claimed in Claim 88, wherein the connecting mechanism releases slide of the main head (10)
20 with respect to the rod (9), when the force exerted on the main head (10) exceeds a given threshold value.

90) A method as claimed in one of Claims 1 to 89, wherein the rod (9) of the pile (3) differs in thickness and/or shape along the longitudinal axis of the pile (3);
25 the rod (9) being made of metal, and comprising a number of segments, which are driven successively through the respective hole (4) and are joined to one another to define the rod (9); the component segments of the rod (9)

differing in shape and/or thickness.

91) A method as claimed in one of Claims 1 to 89, wherein the pile (3) comprises a jacket of cement material (31) surrounding the rod (9); the transverse
5 dimension of the jacket of cement material (31) of the pile (3) differing along the longitudinal axis of the pile (3).

92) A method as claimed in Claim 91, wherein the difference in the transverse dimension of the jacket of
10 cement material (31) is achieved by adjusting the transverse dimension of the main head (10) as the main head (10) is driven in.

93) A method as claimed in Claim 91, wherein the difference in the transverse dimension of the jacket of
15 cement material (31) is achieved by differentially injecting the cement material (31) through at least one through hole (52) formed along the rod (9).

94) A method of constructing a pile foundation; the method comprising the steps of building on the ground (2)
20 a foundation structure (1) having at least one through hole (4); inserting a metal pile (3), comprising a rod (9) and at least one bottom main head (10), through said hole (4), so that the main head (10) of the pile (3) contacts the ground (2); statically applying at least one
25 thrust on the pile (3) to drive the pile (3) into the ground (2); and fixing the driven pile (3) axially to said foundation structure (1); the method being characterized in that the main head (10) is pointed.

95) A method as claimed in Claim 94, wherein the inclination of the pointed tip of the main head (10) is adjustable, when driving the pile (3), as a function of the characteristics of the ground (2).

5 96) A method as claimed in Claim 94 or 95, wherein the main head (10) is rotated at a given speed about its central axis of symmetry.

97) A method as claimed in Claim 96, wherein the main head (10) comprises a number of helical grooves to
10 screw the main head (10) into the ground (2).

98) A method as claimed in Claim 97, wherein the main head (10) is screwed into the ground (2) with no extraction of material from the main channel (28).

99) A method as claimed in Claim 97, wherein the
15 main head (10) is screwed into the ground (2) with extraction of material from the main channel (28).

100) A method as claimed in one of Claims 94 to 99, wherein at least one connecting member (5) is fixed to the foundation structure (1), adjacent to the hole (4);
20 the static thrust on the pile (3) to drive the pile (3) into the ground (2) being applied using the foundation structure (1) as a reaction member.

101) A method as claimed in Claim 100, wherein appropriate ballast, resting on the foundation structure
25 (1), is added to the foundation structure (1) at the hole (4).

102) A method as claimed in one of Claims 94 to 99, wherein drive ballast, physically separate from and not

resting on the foundation structure (1), is provided; the static thrust on the pile (3) to drive the pile (3) into the ground (2) being applied using the drive ballast as a reaction member.

5 103) A method as claimed in Claim 102, wherein the drive ballast comprises a mass resting on the ground (2).

104) A method as claimed in Claim 103, wherein the mass of the drive ballast is fixed temporarily to the ground (2) by means of a number of auxiliary piles or
10 screws driven temporarily into the ground (2).

105) A method as claimed in Claim 103 or 104, wherein the mass of the drive ballast is mounted on a movable structure.

106) A method as claimed in Claim 105, wherein the
15 mass of the drive ballast is supported on wheels.

107) A method as claimed in Claim 105, wherein the mass of the drive ballast is supported on a floating body.

108) A method as claimed in one of Claims 94 to 107,
20 wherein thrust is applied by means of a respective thrust device (21) comprising at least two hydraulic jacks located on opposite sides of the rod (9).

109) A method as claimed in Claim 108, wherein the movable output member of each hydraulic jack is fixed to
25 a fixed horizontal plate, and the bodies of the two hydraulic jacks grip the rod (9) to engage the rod (9) and draw the rod (9) downwards when the output members of the jacks are extracted from the bodies of the hydraulic

jacks.

110) A method as claimed in Claim 109, wherein the bodies of the two hydraulic jacks grip the rod (9) by means of wedges, which tend to compress the rod (9) as the bodies of the hydraulic jacks descend.

111) A method of constructing a pile foundation; the method comprising the steps of building a foundation structure (1) on the ground (2); driving at least one auxiliary pile into the ground (2) when building the foundation structure (1); and removing the auxiliary pile once the foundation structure (1) is completed; the method being characterized in that, to remove the auxiliary pile, the auxiliary pile is subjected statically to pull generated by an extracting device connected mechanically at one end to a top end of the auxiliary pile, and resting at the other end on the foundation structure (1), which acts as a reaction member for the extracting device.

112) A method as claimed in Claim 111, wherein the extracting device comprises at least two hydraulic jacks on opposite sides of the auxiliary pile; the movable output member of each hydraulic jack being connected mechanically to the auxiliary pile; and the bodies of the two hydraulic jacks resting on the foundation structure (1).

113) A metal pile (3) for constructing a pile foundation, and comprising a rod (9), and at least one bottom main head (10); the pile (3) being inserted

through a through hole (4) in a foundation structure (1) on the ground (2), so that the main head (10) of the pile (3) contacts the ground (2); at least one thrust being applied statically on the pile (3) to drive the pile (3) into the ground (2); and the driven pile (3) being fixed axially to the foundation structure (1); the pile (3) being characterized in that the transverse dimensions of the main head (10) are greater than those of the hole (4) when driving the main head (10) into the ground.

10 114) A metal pile (3) for constructing a pile foundation, and comprising a rod (9), and at least one bottom main head (10); the pile (3) being inserted through a through hole (4) in a foundation structure (1) on the ground (2), so that the main head (10) of the pile
15 (3) contacts the ground (2); at least one thrust being applied statically on the pile (3) to drive the pile (3) into the ground (2); and the driven pile (3) being fixed axially to the foundation structure (1); the pile (3) being characterized in that the main head (10) is
20 pointed.

115) A metal pile (3) for constructing a pile foundation, and comprising a rod (9), and at least one bottom main head (10); the pile (3) being inserted through a through hole (4) in a foundation structure (1)
25 on the ground (2), so that the main head (10) of the pile (3) contacts the ground (2); at least one thrust being applied statically on the pile (3) to drive the pile (3) into the ground (2); and the driven pile (3) being fixed

axially to the foundation structure (1); the pile (3) being characterized in that the rod (9) differs in thickness and/or shape along the longitudinal axis of the pile (3).

5 116) A metal pile (3) for constructing a pile foundation, and comprising a rod (9), and at least one bottom main head (10); the pile (3) being inserted through a through hole (4) in a foundation structure (1) on the ground (2), so that the main head (10) of the pile
10 (3) contacts the ground (2); at least one thrust being applied statically on the pile (3) to drive the pile (3) into the ground (2); and the driven pile (3) being fixed axially to the foundation structure (1); the pile (3) being characterized by comprising a jacket of cement
15 material (31) surrounding the rod (9); and the transverse dimension of the jacket of cement material (31) of the pile (3) differing along the longitudinal axis of the pile (3).

20 117) A pile (3) as claimed in Claim 116, wherein the jacket of cement material (31) at an intermediate segment of the pile (3) has a larger transverse dimension than at a top end segment of the pile (3).

25 118) A pile (3) as claimed in Claim 116, wherein the jacket of cement material (31) at a bottom segment of the pile (3) has a larger transverse dimension than at a top end segment of the pile (3).